



Available online at www.sciencedirect.com



Journal of Forensic and Legal Medicine 14 (2007) 275–278

JOURNAL OF
**FORENSIC
AND LEGAL
MEDICINE**
www.elsevier.com/jflm

Original communication

Death in epileptic people: a review of Manitoba's medical examiner's cases

Sholeh Barooni MD (Assistant Professor)^{a,*}, A. Thambirajah Balachandra MBBS, FRCPC (Chief Medical Examiner)^b, Lesley Lee (Medical Examiner's Investigator)^c

^a Department of Forensic Medicine, Tehran University of Medical Sciences, Ghods Avenue, Poursina Street, Tehran 14155, Iran

^b Department of Pathology, Faculty of Medicine, University of Manitoba, Winnipeg, Man., Canada

^c Medical Examiner's Investigator, Office of the Chief Medical Examiner, Manitoba Justice, Winnipeg, Man., Canada

Received 4 September 2006; received in revised form 3 October 2006; accepted 30 October 2006

Available online 19 January 2007

Abstract

Studies of cause-specific mortality show that deaths of epileptic people can be classified into those directly or indirectly related to epilepsy; those related to the underlying pathology giving rise to epilepsy; and those unrelated to either epilepsy or its causes. In this descriptive retrospective study, medical examiner's cases that occurred in Manitoba, Canada during 2004 were reviewed. One hundred and seventeen cases (4.06%) had epilepsy in their history. Cause of death was related directly to seizure in 12 cases (10.3%) and indirectly in six cases (5.1%); related to underlying pathology giving rise to epilepsy in 33 cases (28.2%); and unrelated to either of them in 60 cases (51.3%). Cause of death was unknown in six cases (5.1%). The causes of death, in order of frequency, were cardiac pneumonia, cerebrovascular accident and seizure disorder. Manner of death was natural in 86 cases (73.5%), accidental in 19 cases (16.2%), suicidal in five cases (4.3%), undetermined in five cases (4.3%) and homicidal in two cases (1.7%). While the mean age of the deceased persons with a positive history of seizure in this study was about 10 years less than those with a negative history of seizure, there was no significant difference between them in the manner of death. Epileptic people are not at greater risk for accidental death or suicide; however they are at greater risk for drowning. Recently diagnosed cases of epilepsy are at greater risk of dying from seizure or underlying pathology during the first year of their disease.

© 2006 Elsevier Ltd and AFP. All rights reserved.

Keywords: Epilepsy; Manner of death; Cause of death

1. Introduction

The lifetime likelihood of having at least one febrile or nonfebrile epileptic seizure is about 9%, and the lifetime likelihood of receiving a diagnosis of epilepsy is almost 3%. However, the prevalence of active epilepsy is only 0.8%.¹ It is reliably established that mortality in epilepsy is increased as much as threefold compared to an age-matched general population.^{2–5} Studies of cause-specific mortality show that deaths can be classified into those directly or indirectly related to epilepsy; those related to the underlying pathology giving rise to epilepsy; and those

unrelated to either epilepsy or its causes. Overall, death as a direct result of epilepsy is infrequent. Pneumonia, especially in the elderly, central nervous system (CNS) and non-CNS neoplasias, and cerebrovascular disease are frequent causes of death.⁶ The spectrum of causes of death that are not related directly to the occurrence of seizures in persons with epilepsy is similar to that of the general population, with the most common diagnoses being cerebrovascular disease, CNS tumor, alcohol-related problems, and congenital neurological deficits.^{7,8} If deaths were directly or indirectly related to epilepsy and epilepsy is the result of trauma, the manner of death will be accidental, suicidal or homicidal depending on how the trauma was inflicted. This will have repercussions in payment of deaths benefits by life insurance companies and also legal

* Corresponding author. Tel.: +98 21 6640 5588; fax: +98 21 6640 5588.
E-mail address: barooni@sina.tums.ac.ir (S. Barooni).

implications in homicide cases. Further knowledge regarding death among epileptics, either directly or indirectly related to the disease, may provide useful insights into preventing future deaths. The purpose of this retrospective study, therefore, was to review cause of deaths and other features of epileptics in medical examiner's cases from Manitoba for 2004.

2. Method

In the Province of Manitoba, Canada, unexpected, sudden, and unnatural deaths are reported, inquired into, and investigated by a medical examiner's system governed by The Fatality Inquiries Act. All reported cases are inquired into with respect to demographics and date, time, cause and manner of death. Selected cases are fully investigated and may include a full autopsy and toxicological analysis. Inquiries and investigations are done by medical examiners and medical examiner's investigators with the assistance of the local police departments. In doing so, the body is viewed, scene inspected if the body is still at the scene, and inquiries made from the deceased's physicians with regard to medical history including epilepsy. In this descriptive retrospective study, medical examiner's cases in Manitoba that occurred during 2004 ($n = 2965$) were reviewed. Data was collected from the paper files maintained in the Office of Chief Medical Examiner. In cases where the data in the files was insufficient or incomplete, the medical charts were reviewed and the files updated. Cases that were excluded included newborn subjects (less than four weeks of age); those with an incomplete medical history; and those with a history of febrile seizures or no documented seizures. In total, 90 cases were excluded. Therefore, of the 2875 reviewed cases, 117 cases (4.06%) had epilepsy in their history.

Cases were reviewed by a medical examiner and data was collected on medical history, seizure description, and post-mortem findings. Epileptic cases were categorized according to the ILAE Guidelines for Epidemiologic Studies.⁹

The following factors were assessed: age, sex, duration of epilepsy, seizure condition, whether or not the deceased used antiepileptic drugs (under medication), alcohol and/or other substance abuse, place of death and evidence of terminal seizure, cause of death and its relation to seizure and manner of death. Factors such as age of the deceased and sex, cause and manner of death were assessed in cases where the subjects had negative history for epilepsy (NHE) ($n = 2758$) and considered in a different group.

The probable etiology of epilepsy was finally determined on the basis of clinical details and examination of the brain at autopsy. Epilepsy was classified as idiopathic epilepsy in those individuals who were developmentally normal, had no significant neurological abnormalities, and no known underlying cause for epilepsy. Epilepsy was classified as symptomatic epilepsy in those individuals with known underlying cerebral, metabolic or genetic disorder or in those where findings of intellectual deficiency and/or signif-

icant neurological abnormalities were found and therefore were suspect.¹⁰

The population of Manitoba in 2004 was 1,169,667 (Manitoba health population report), mortality rate was 8.49 per 1000 population (Manitoba vital statistics). Medical examiner's cases (population base for this study $n = 2965$) accounted for 29.9% of the total number of deaths in Manitoba for 2004. Autopsies were done in 1167 of the reported cases and toxicology was done in 659 of the cases.

This study was done under the supervision of the Chief Medical Examiner, Province of Manitoba and followed the code of American Medical Association Revision of Code of Medical Ethics. Data were analyzed using descriptive analysis, such as χ^2 , *t*-test and fisher-exact test.

3. Results

Out of the 117 cases with a positive history for epilepsy (PHE), 71 cases (60.7%) were male and 46 cases (39.3%) female. The mean age was 54.13 years (max: 90 years, min: 5 months, SD: 22.81).

The causes of epilepsy are summarized in Table 1. The cases have been divided into three age groups: childhood, adulthood and seniors. As it can be concluded from Table 1, no clear etiology was diagnosed in seventy cases (59.8%) (idiopathic seizure). Among the other 47 cases (40.2%), congenital anomalies, alcohol related problems, post stroke condition, brain tumors, cerebral palsy, and multiple sclerosis were the most common etiologies in descending order. In one case, hypoxic encephalopathy due to hanging was reported as the cause of epilepsy. The subject died three months later due to seizure.

Table 2 shows the type and frequency of antiepileptic medication in use, based on epilepsy condition and post-mortem drug analysis. Seventy-eight cases (66.7%) had active seizure and 102 cases (87.2%) were under medication. The most used medications were phenytoin, phenobarbital and carbamazepine.

Seizure was the direct cause of death in 12 cases (10.3%). In six cases (5.1%) seizure was diagnosed to be an indirect cause of death. Underlying pathology causing epilepsy was the cause of death in 33 cases (28.2%). In 60 cases (51.3%)

Table 1
Causes of epilepsy in different age groups

Causes of epilepsy	Age (in years)			Total
	<18	18–64	>64	
Idiopathic	1	34	35	70
Congenital disease	5	10	1	16
Alcohol related	–	12	1	13
Post stroke	–	4	4	8
Brain tumor	–	3	1	4
Brain trauma	–	–	2	2
Cerebral palsy	1	1	–	2
Encephalopathy	1	–	–	1
Multiple sclerosis	–	1	–	1
Total	8	65	44	117

Table 2

Epilepsy condition and result of postmortem drug analysis versus use of medication in deceased epileptics

Under medication	Epilepsy condition (<i>n</i> = 117)			Postmortem drug analysis (<i>n</i> = 35)		
	Remission	Active seizure	Unknown	Positive in therapeutic range	Positive in toxic range	Negative
Yes	7	76	19	16	4	11
No	10	2	1	—	1	3
Unknown	—	—	2	—	—	—
Total	17	78	22	16	5	14

death was neither caused by seizure itself nor by the underlying etiology. Cause of death remained undiagnosed in six cases (5.1%).

Duration of epilepsy was less than one year in 10 cases (8.5%) while in all of them the cause of death was related to seizure or its underlying pathology. Table 3 shows manner of death in relation to the cause of death. Table 4 shows manner of death and seizure-death relationship. Death happened in a natural way in 86 cases (73.5%), accidental

in 19 cases (16.2%), suicidal in five cases (4.3%), undetermined in five cases (4.3%) and homicidal in two cases (1.7%).

Autopsies were performed in 44 cases (37.6%) and in 35 cases where toxicological analysis for drug detection had been done, five cases (14.3%) showed positive drug levels in the toxic range. (Olanzapine in 2, Acetaminophen in 1, opiates in 1 and opiates plus cocaine in 2). Nine cases had ethanol in their blood with a mean concentration of 374.13 mg/dl (SD: 100.479).

The causes of death in order of frequency were cardiac deaths, pneumonia, CVA and seizure disorder (Table 3). Drowning was the cause of death in four cases (3.4): two drowned in the bath at home while the others were found in a public pool and a river. The manner of death was undetermined in the latter case but the rest of the deaths were classified as accidental. There was one case of sudden unexpected death (0.9% in PHE group): a 30 year old female with idiopathic epilepsy since age four and who had daily seizures for two to three minutes. She also had a medical history of type 2 diabetes and thyroid problems. She was on carbamazepine and divalproex. Postmortem blood analysis revealed a subtherapeutic level of carbamazepine.

Out of 2758 NHE cases, 1664 (60.3%) were male and 1094 (39.7%) female with a mean age of 65.78 years (max: 104 year, min: 1 year, SD: 21.01). The mean age for the female subjects was 69.75 and for male subjects, 63.16. It should be noted that the mean age was significantly higher in females ($P < 0.0001$).

The manner of death was natural in 2120 cases (76.9%), accidental in 405 cases (14.7%), suicidal in 148 cases (5.4%) and homicidal in 47 cases (1.7%). Thirty-eight cases (1.4%) were classified as undetermined. The most common cause of death was cardiac death. There were 29 cases (1.05%) of drowning with 23 cases determined as accidental (79.3%) and six as suicidal (20.7%).

Table 3

Manner/cause of death in epileptic group

Manner/cause of death	Number of cases (<i>n</i> = 117)
<i>Natural</i>	
Cardiac	25
Respiratory	17
CVA	9
Seizure disorder	6
Other	22
Total	86
<i>Accident</i>	
Fall	7
Al-drug related	5
Drowning	3
Asphyxia	2
Car accident	2
Total	19
<i>Suicide</i>	
Drug toxicity	2
Hanging	2
Shot gun	1
Total	5
<i>Homicide</i>	
Hanging	1
Strangulation	1
Total	2
<i>Undetermined</i>	
Total	5

Table 4

Seizure-death relation according to manner of death

Seizure-death relationship	Manner of death					Total
	Natural	Accident	Suicide	Homicide	Undetermined	
Related directly to seizure	8	2	—	—	2	12
Related indirectly to seizure	4	1	—	—	1	6
Related to underlying pathology giving rise to seizure	27	4	1	—	1	33
Unrelated to both seizure and underlying pathology	46	8	4	2	—	60
Unknown	1	4	—	—	1	6
Total	86	19	5	2	5	117

4. Discussion

The mean age in the NHE group was 10.5 years more than for the PHE group which was significant ($P < 0.001$). There was no significant difference between the sex related mean age in PHE but there was in the NHE ($P < 0.0001$).

It was found that 15.4% of the deaths in the PHE group were seizure related and 28.2% were related to underlying pathology while in the Bordeaux cohort study the cause of death was seizure-related in 5.9% of cases, due to progression of underlying disease in 63.6%, unrelated to seizure etiology in 21.2% (including one suicide), and unknown because of insufficient information in 9.3% of the cases.¹¹

Epileptic population with known exact duration of epilepsy ($n = 71$) was divided into two groups: those who had suffered from seizure(s) less than one year (recently diagnosed) and those with more than a one year history of seizure(s). Cause of death and its relationship with epilepsy was then estimated. In recently diagnosed people, cause of death was significantly related to epilepsy or underlying pathology giving rise to epilepsy (Exact sig. 2-sided = 0.004, CI: 1.53–2.519). Rufo-Campos has mentioned that the underlying disease, of which epilepsy is a symptom, is the main cause of death in new cases, while the epilepsy itself is a major cause in chronic epilepsy.¹²

Sudden unexpected deaths in epilepsy in our study was 0.3 in 1000 persons per year while in other medical examiner's studies it was 0.5–2.7 in 1000 person-years.¹³

There was not a major difference in manner of death in both groups of NHE and PHE. About 1% to 16% of deaths in epileptic patients may be a consequence of accidents.¹⁴ These usually occur while swimming or bathing. In one Canadian study, 5% of all drowning deaths were attributable to seizures, with 60% of them occurring in bathtubs.¹⁵ In the present study, 1.05% of deaths in the NHE group were due to drowning and 80% of those drowning deaths were accidental. In the PHE group, 3.4% of the deaths were due to drowning with 75% of them being accidental. This shows that epilepsy increases the risk for drowning ($P < 0.001$), which is coherent with other studies.^{16,17}

The National General Practice Study of Epilepsy (NGPSE) in the United Kingdom has confirmed that pneumonia is a common terminal event in the elderly, and the mean age of patients who died of pneumonia in the NGPSE was 81.3 years.² In the present study it was 57.58 years.

5. Conclusion

While the mean age of deceased persons with PHE considered in this study were about 10 years younger than in other studies, there was no significant difference in the manner of death. Epileptic individuals are not at greater risk for accidental death or suicide; however, they are at

greater risk for drowning. People with epilepsy should be encouraged to take showers while sitting instead of baths. The presence of another person in the same house, but not directly supervising the person in the bathroom does not protect against drowning. Personal flotation devices should be worn at all times during boating activities.

Individuals with recently diagnosed epilepsy are at a greater risk of dying from seizure or underlying pathology during the first year of their disease.

Acknowledgements

The authors thank the staff in the Office of the Chief Medical Examiner for their assistance and, in particular, Mr. G. Holens for his help with the statistical analysis and Ms J. Christianson-Wood and Mrs. C. Ring for their editorial input.

References

1. Cavazos JE, Lum F. Seizure and epilepsy: overview and classification. www.emedicine.com/neuro/topic415.htm. last updated: December 16, 2005.
2. Cockerell OC, Johnson AL, Sander JW, et al. Mortality from epilepsy: results from a prospective population-based study. *Lancet* 1994;**344**:918–21.
3. Hauser WA, Annegers JF, Elveback LR. Mortality in patients with epilepsy. *Epilepsia* 1980;**21**:399–412.
4. Olafsson E, Hauser WA, Gudmundsson G. Long-term survival of people with unprovoked seizures: a population based study. *Epilepsia* 1998;**39**:89–92.
5. Zielinski JJ. Epilepsy and mortality rate and causes of death. *Epilepsia* 1974;**15**:191–201.
6. Lhatoo SD, Josemir WA, Sander JW. Cause – specific mortality in epilepsy. *Epilepsia* 2005;**46**(Suppl. 11):36–9.
7. Morgan CL, Kerr MP. Epilepsy and mortality: a record linkage study in a UK population. *Epilepsia* 2002;**43**:1251–5.
8. Lhatoo SD, Johnson AL, Goodridge DM, MacDonald BK, Sander SD, Shorvon SD. Mortality in epilepsy in the first 11 to 14 years after diagnosis: multivariate analysis of a long-term, prospective, population-based cohort. *Ann Neurol* 2001;**49**:336–44.
9. Commission on epidemiology and prognosis of the ILAE. Guidelines for epidemiologic studies on epilepsy. *Epilepsia* 1993;**34**:592–6.
10. Commission on classification and terminology of the international league against epilepsy. Proposal for revised classification of epilepsies and epileptic syndromes. 399. *Epilepsia* 1989;**30**:389.
11. Loiseau P, Loiseau J, Picot MC. One-year mortality in Bordeaux cohort: the value of syndrome classification. *Epilepsia* 2005;**46**(Suppl. 11): 11–4.
12. Rufo-Campos M. Mortality in epilepsies. *Rev Neurol* 2000; **30**(Suppl. 1):S110–4. Review.
13. Tomson T, Walczak T, Sillanpaa M, Sander JW. Sudden unexpected death in epilepsy: a review of incidence and risk factors. *Epilepsia* 2005;**46**(Suppl. 11):54–61.
14. Nashef L, Sander JW, Fish DR, et al. Incidence of sudden unexpected death in an adult outpatient cohort with epilepsy at a tertiary referral centre. *J Neurol Neurosurg Psychiatry* 1995;**58**:462–4.
15. Krohn W. Causes of death among epileptics. *Epilepsia* 1963;**4**:315–21.
16. Day SM, Wu YW, Strauss DJ, Shavelle RM, Reynolds RJ. Causes of death in remote symptomatic epilepsy. *Neurology* 2005;**65**(2):216–22.
17. Ryan CA, Dowling G. Drowning deaths in people with epilepsy. *CMAJ* 1993;**148**(5):781–4.